SCIENCE EDUCATION IN SCHOOLS

Report of the Indian Parliamentary and Scientific Committee

NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

No. 125—C—23
25,000 Copies
May 1965

Reprinted by the National Council of Educational Research and Training through the courtesy of the Publications Division of the Ministry of Information and Broadcasting, Government of India.

PUBLISHED BY SHRI P. N. NATU ON BEHALF OF THE NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING, 16, RING ROAD, NEW DELHI AND PRINTED AT DELHI PRESS, JHANDEWALAN, NEW DELHI.

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FOREWORD

In our present-day society it has been increasingly felt that the influence of science should be brought to bear on the formulation of public policies For this it is necessary that parliamentarians—the makers of policies—should be well aware of the developments in science and technology and be acquainted with the scientific point of view It was with the purpose of bringing parliamentarians and scientists together on a common platform for discussion and exchange of ideas, which could be useful to both, that the Indian Parliamentary and Scientific Committee was formed in August 1961.

In view of the importance of science education, a Seminar on 'The Place of Science in Secondary Education' was held at the inaugural meeting of the Committee, in which Dr. D. S. Kothari Dr. A. C. Joshi and others participated. Later, a Study Gruop was formed with Shri H. C. Dasappa, M.P, now Minister of Railways, as Chairman and Shri Kishan Kant, one of the Secretaries of the Indian Parliamentary and Scientific Committee, as Convener and the subject of Science Education in Schools was taken up. A number of meetings were held in which, besides Membrs of Parliament, experts from the Ministry of Education, Planning Commission, University Grants Commission and others participated. The Committee is thankful to these organizations and the experts who supplied the necessary information for discussion and helped in the formulation of the report. Thanks are also due to Shri K. L. Joshi, then Chief of the Education Division, Planning Commission, and now Secretary, University Grants Commission, who undertook to draft the report.

The report was generally approved at a meeting of the Committee held on the 17th September, 1963, which has presided over by Prof. Humayun Kabir, then Minister In-charge

of Education and Scientific Research and Cultural Affairs. The final report is now being released in the hope that it would provoke further discussion on this important problem of encouraging the teaching of science in schools.

LAL BAHADUR SHASTRI,
Chairman,
Indian Parliamentary and Scientific Committee

CHAPTER I

INTRODUCTION

1 01. The Indian Parliamentary and Scientific Committee took up for study and examination early in 1962 the problem of 'Science Education in Schools' with a view to finding out the position of how science courses are organised in our primary, middle and high/higher secondary schools in relation to policies and decisions arrived at the Centre and the States when the Third Plan commenced We had several meetings of the committee and Members of Parliament of both the Houses took keen interest in the subject. We were guided in our deliberations by experts and officers of the Ministry of Education, Planning Commission, University Grants Commission and Delhi University.

Objective of the study

1 02. As a Committee of the Members of Parliament our purpose was not to cover the field in the sense in which an expert commission or technical committee is expected to deal with the question. The main objective of the study was to acquaint the Members of Parliament with this important problem and to see how they could assist through government machinery and other organisations in the States and at the Centre in improving science teaching in our schools and attaining those objectives which have been enunciated by different expert committees of the Ministry of Education and in the reports of the Planning Commission.

1.03. This informal approach has been rewarding to us in many ways. We did not claim ourselves to be an expert body or a body of legislators with a set purpose of analysing the problem into various details and making recommendations in regard to improvements and financial implications for such a development or to suggest legislative measures for execution of policies. In fact, this work is already being done in the Government through the existing machinery of the Planning Commission and the Central

Ministries. Similarly, we have been aware that the State Governments have also been deliberating over the question and the Third Plan has emerged in the States as a result of this all-round thinking. The main policies of development have been enunciated in the Report of the Third Five Year Plan.

Procedure for the study

1.04. As an informal Committee of the Members of Parliament, we thought it was not necessary for us to issue any questionnaire or to go round the country to check up how things were actually being implemented or to get witnesses to record evidence about the various problems. We could discuss the material placed before us by the experts of the different Ministries and the Planning Commission and could assess in a general way the nature of the problem as well as its implications. Indeed whenever we had visited our constituencies, we had heard several complaints about the lack of teachers of science, lack of buildings, lack of equipment and apparatus for science teaching. Some of us have been closely associated with one educational body or the other and we could get confirmation in the committee discussion of several points which had come to us through reports of different schools and private and government educational institutions. We stated in our discussions the facts we had known and we learnt more facts from the different experts associated in our deliberations. This report is, therefore, intended to be an expression of our general judgment of the situation based on our limited knowledge of the problem and guided by the expert advice available to the committee.

1.05. We think that the informal nature of this Committee has been helpful in providing a focus for discussing and forming views about the various issues. This would not only help the Members of Parliament and others interested in the important issues involved but also when a question comes up before the parliament related to the issues, it would be possible for members to throw light and make suggestions for programmes of development. Secondly, it is possible for the public to influence various institutions and also the State Governments in the thinking which we could share with others and thus create

a climate for realistic appraisal of difficulties and their possible solutions.

1 06. The Indian Parliamentary and Scientific Committee is an informal all-party group and would be continuously studying this particular problem with occasional reports and information pamphlets. This is, of course, the first report of the committee. But it is possible that more members of both the Houses would be interested in its work along with nominated representatives of scientific and technological organisations in the country, so that further appraisal of allied questions is done in the light of the reactions of the public, the Central Ministries, State Governments, and various educational institutions and experts.

1 07. we have undertaken the study of scientific education in schools as the first of our series because it is the foundation for an scientific education and for the training of scientists and technologists, medical and agricultural experts at all levels whom we need in much larger numbers in relation to our technological development and progress in industrial, agricultural and social sectors. We propose to take up the study of similar problems at the higher stages of education at a later stage but that would involve us in the study of various specialised fields in which the facilities for education and training are being expanded rapidly during the last 10 years and need to be constantly watched by all of us interested in the economic development of the country. Building up of trained manpower through our institutions and different programmes of specialised training is an essential condition for development of our economy as a whole, whether it is related to the present emergency or not. We believe that all economic planning has to be done with the same sense of urgency as endures through an emergency and has to take care of priorities of programmes and their implementation with a sense of great national cause or mission. Basic to this programme is the way in which the nation's children are educated and the society is able to transmit from one generation to the next the values, knowledge and skills which should ensure its survival.

1.08. For this purpose, the attitudes of society towards the problem of development and education are important. We regard

these as even more important than the institutions that have specific responsibility for developing and educating the young.

1.09. In the field of education, apart from the constitutional directive that all children up to the age of 14 must be compulsorily brought to school, during 10 years' planning, we have realised that all education and training has to be not only for the purpose of transmitting our traditional values and knowledge to the next generation but also for building up a base of responsible citizens and for trained manpower so that requirements in terms of human resources for developing the economy could be assessed from time to time and suitable programmes of education and training instituted, modifying and improving them in relation to the requirements of our economy, as it develops in future.

1.10. The present emergency has made us increasingly aware of the role of science and technology and that science is dynamic and the tempo of the modern world is not conducive to any sense of complacency

1.11. We ask the question whether there was a gap between our aspirations and hopes of educational development and our accomplishments in preparing young people for life through programmes of science education and training. If, in our opinion, there is a gap, the second question is what can be done to narrow it and the way in which this should not be allowed to persist.

CHAPTER II

THE PROBLEM

Changes in science education and new demands

2.01. The need for changes in the system of science educatio- from the school to the highest level is a post-Second War developn ment in nearly all advanced countries of the western world In India this became keenly felt in the post-Independence period, particularly through the efforts at planned development.

2.02. New developments in science and technology following World War II resulted in certain adjustments in our courses, but in the western world there was an unprecedented eruption o activity in science education since 1950's. In the U.S.A. it has been stated that awareness of serious shortages of technically educated manpower was felt by educators, industrialists and Government policy-makers after 1955. In 1957 when the Russian Sputnik was known to the world, this concern about scientific and technological education became greatly intensified and both in the U.K. and the U.S A. steps have been taken to see that scientists and technologists are trained in adequate numbers to meet the new technological revolution as well as the requirements of a technological age. That science and technology can achieve the results of economic development, particularly for backward countries, in the shortest time possible in order to raise the standards of living and economic wellbeing was realised by both the developing and the well-developed countries. Nicholas De Witt in "Soviet Professional Manpower 1955," a publication of the National Science Foundation, Russian Research Centre, Harvard University, 1955, compared the educational system of the U.S.S.R with that of the U.S A. pointing out how scientists and technologists were trained in larger numbers in the U.S S R. through an educational system in which science and mechanics were introduced in a graded form throughout the school course. The author also pointed out clearly how the U.S.S.R. were

determined to produce the maximum number of scientists and technologists and had announced a target of 50 cer cent increase in the number of professional engineers in the shortest time possible. The British White Paper on Technical Education in 1956 emphasised the awareness of the U K to examine whether the British system of scientific and technical education bears comparison with what was being done in other western countries. They aimed at strengthening the foundations of the educational system, fo that strengthened the economy of the U.K and improved the standards of living of the people. They were faced, they said, with an intense and rising demand for scientific manpower and by no means only for men and women with the highest qualifications

2 03. The wind that blew over the western world has touched India and through the documents of the Second and Third Plans, the emphasis on manpower and scientific and technological personnel reflects this intensive thinking on the part of educationists, social thinkers and economic planners of our country.

Resistance to changes

2.04. A tradition-bound educational system resists changes often by not paying heed to the new ideas or new thinking, but when pressed further, often ends in ill-considered compromises and a course of static devotion to the old concepts of syllabus formulation The questions as to how science is taught in our schools and colleges, how textbooks and other printed resources and equipment and materials are made available and how teachers teach in our schools, however, started about this time and both political and social awakening made education-planners science-conscious.

Recognition of the need for science

2.05. Some issues, therefore, became clear during the last 7 or 8 years. This is seen from the documents of the Ministry of Education and their various committees and their reports as well as the reports of the Planning Commission. It was felt that some of the problems facing India in science education were of long standing but others were of recent date which arose out of a feeling of achieving economic goals quickly through the application of modern science and technology. It was realised that the

foundation of a scientist or a technologist was good science-oriented education. While examining this problem, it was recognised that (a) growth of school population (b) shortage of qualified teachers (c) accelerated achievements in science (d) the demand for increase in technically trained manpower (e) the growing importance of science in the affairs of mankind (f) changes in the processes and goals of science and (g) the views held by different thinkers in regard to the structure of the school system and the content necessary for education of youth—are important aspects of one and the same problem of adapting the educational process to modern needs. These problems are interlinked with the questions of finance, organisation of schools, training of teachers, size of schools and colleges, availability of equipment and textbooks.

The questions raised in the discussions of this committee only reflected what has been so much in the air in the country

Science and the modern world

2.06. The whole structure of scientific education in our schools is a very recent development. Even in England a hundred years ago in the best schools like Winchester, Eton or Harrow there could be teaching of nature study in general terms but systematic study of Chemistry or Physics was not thought of It is during the last hundred years that the study of science and its application has grown so much in the western world. The cumulative effect of changes worked out by science and technology effect every aspect of human existence today. Our traditional ideas of human institutions and systems of human thought are undergoing a revolutionary change on account of the impact of science and technology. It goes deep into political, religious and philosophical concepts which have been nursed through centuries and which are being shaken every moment a new scientific discovery is made.

During the last 25 years, this impact of science has been intensified by what might have been thought of as impossible a few decades earlier like the discovery of radio-waves, nuclear fission and the rocket motor. The system of quick transport, speedy communication of ideas through the radio, telephone and television, manufacture of devices for economy and efficiency in every-day living are illustrations of the importance of application of science

to the tempo of modern living and of the economic uses to which technology and science could be put.

Science and culture

2.07. "Through the practical applications of scientific discovery our civilisation is undergoing constant change. In turn, these changes bring about situations which threaten the well-being of future generations. The welfare of our civilisation is now almost wholly dependent upon scientific progress. Society must respond with adequate and intelligent control."* This quotation sums up the approach to science and culture. Scientists would no longer stand by with closed eyes and dumb mouths. In cooperation with other responsible citizens they must take action upon vital issues. Science in our culture is a creative intellectual activity leading to unifying concepts of man's natural environment.

2.08. Today no sector of human activity is untouched by the results of scientific thought. Besides, modern society depends so much on the ideas and devices that emerge as a consequence of scientific research.

2.09. The question to consider in our educational content at the school level is the proportion of science education in relation to what it ought to be as an influence of science in actual life. The second question is how soon the school-going children should know elements of science and in what graded courses it should be inter-locked with the general system of education for cultural development. The Parliament of Science held by the American Association for the Advancement of Science in March 1958 expressed their view in the following way:

> "We believe that the primary goal of education should be the intellectual development of the individual. With its accelerating importance in our society, science has become an increasingly important part of general knowledge. We believe that scientific education is best fostered as a part of a general emphasis on intellectual activity and that the present need is

*Rethinking Science Education, Year Book 1959—Part 1, 1960, p. 17.

for increased support of social sciences and humanities as well as the natural sciences."*

Place of science in education

2.10. A view is generally held that education in science and mathematics and other subjects could be improved by raising university and college entrance requirements and enriching and modernising the content of these subjects at the secondary school level. This has to be done in consultation with the representatives of secondary schools and their administrators.

Education of the scientists is a different proposition from inclusion of science itself in the system of general education. The later has to be inculcated in the school stage. The former is a matter of providing greater facilities and opportunities for higher education of the potential scientists, who would be required in larger numbers both as teachers and as personnel occupying responsible positions in government and industry.

2.11. Another question that thus arises is how science and other subjects can be taught most effectively and how the primary intellectual objectives of education can be integrated with the other objectives of the school system. This would seem to take us to the problem of teachers, textbooks, syllabus formation, laboratories, workshops, equipment and the financial requirements for providing necessary facilities.

Change in contents of science courses

2.12. During the last 25 years, objectives of science teaching, as they appeared in educational literature, have changed little, while changes in the nature of science that ought to be taught have greatly increased. Therefore, there is a gulf between what is being taught and what ought to be taught. This could be illustrated by the fact that Mathematics, the purest of all sciences, has to take note of its application in the fields of Physics, Chemistry and Biology, and it would seem to appear that sciences are becoming more unified and thus gain an important position in our daily

*Report published in *Science*, 1958, p 857.

affairs, apart from the significant impact of science on the world affairs and our international living. This would appear to lead to the need to rethink the purposes of teaching science in schools.

Criticism of science teaching

2.13. Criticism of science teaching in the schools and colleges mostly levelled by specialised scientists and other modern thinkers is that the subject of science is made mechanical and routine instead of science teaching reflecting the nature of science and a certain social orientation being grafted into science teaching. Some teachers have also felt that the approach to understanding of science as a search for order in nature seems to be missing in the school curriculum. Science means collection of facts and observations preferably in quantitative terms, the construction of a hypothesis to explain the relation of facts to each other and the selection of further appropriate observation for the carrying out of experiments designed to test the correctness of hypothesis. Moreover, the scientific approach is based on the assumption that the universe is a systematic and ordered place and that every observation, no matter how unexpected, is capable of being fitted into a rational hypothesis. This approach has to be properly integrated into the curricular content of our schools to save the syllabus from being mechanistic and dull. In this approach science would appear to have as many elements of cultural contact with human civilisation as any system of school education which has a preponderance of humanistic subjects.

2.14. Thus, it would seem that reorganisation of science courses would imply that the student should acquire a useful command of science concepts and principles and he has to be as much familiar with the language of science or its vocabulary just as he knows the vocabulary of the classics, history and the creative purposes of literature.

2.15. The educational value of science teaching in this way merits attention because scientific thinking is a process of logical deductions and inculcates among our young generation the spirit of enquiry involving careful observation, seeking the most reliable data and using rational processes to give order to the data and suggest possible conclusions offered by research.

CHAPTER III

THE PRESENT POSITION

3.01. As in the U.K, the U.S.A. and the U S.S.R., our educationists have also been aware of the problem of increased need of scientific and technological personnel for economic development. The Report of the Third Plan has stated, "Owing to the rapid advance in science and technology and the growing complexity of industrial and economic organisation, there is increasing demand for larger numbers of highly skilled and trained personnel drawn from different disciplines and functioning generally in composite teams rather than as individuals. As the economy develops, the requirements of individuals with more advanced and specialised training and of scientifically trained workers increase, while the need for persons at lower levels of skill and for the semi-skilled and unskilled steadily diminishes." (p. 168.) The recognition of the need for science-based education in the schools as a result of the need for scientists and technologists has also come during the last decade and the Working Groups appointed by the Planning Commission to investigate the position of development and requirements for the Third Plan have emphasised the need for building up scientific basis from the school stage, *e.g.*, the Report of the Planning Commission Working Group on Technical Education and Vocational Training (1960, p. 12). "It will be clear that the basis of technical education has to be built up from the school stage by emphasising courses in science mathematics, certain crafts and bias for practical work. It has been pointed out that in Russia the scientific education in high school stage is broad-based and fostered with the greatest zeal. At every such school they have in the top four classes of the 10-year school, the provision for training in scientfic subjects with special emphasis on physics, mathematics and mechanics." The draft report of the Working Group for General Education (1960, p. 69)

stated: "In view of the dominating role of science in the modern world, the Government of India have adopted a policy for the cultivation of science in such a manner as to secure for the nation all the benefits that accrue from the acquisition and application of scientific knowledge. If these aims are to be fulfilled, science education should begin as early in the child's schooling as possible and should continue with a deepening content until the conclusion of the secondary stage."

3.02. The Scientific Policy Resolution of the Government of India, 1958, stated: "The dominating feature of the contemporary world is the intense cultivation of science on a large scale, and its application to meet a country's requirements." For this purpose, they indicated vigorous methods for cultivation and promotion of science.

3.03. The following extract from the Report on the Third Plan is relevant:

"*Science education*: The Second Plan gave high priority to the expansion and improvement of science education at the secondary stage. The Secondary Education Commission had recommended that every secondary school pupil should study general science as a compulsory subject, so that he gains a basic quantum of scientific knowledge as part of his general education. In addition, provision was to be made for science as an elective subject for those students who wished to pursue higher studies. By the end of the Second Plan, a programme of general or elementary science has been introduced in almost all secondary schools, while science of an elective standard has been provided in about 4,625 schools. However, a considerable proportion of schools lack the basic minimum requirements in respect of laboratories and equipment and also suitable textbooks and handbooks. Teachers have to be prepared in the integrated approach which is required in the teaching of general science. It is also necessary to encourage students in creative and original activity in science. This was sought to be done during the second Plan by establishing science clubs in selected secondary schools and training colleges. About 456 such science clubs were established during this period.

In the Third Plan in addition to providing general science in all the secondary schools as a compulsory subject more than 9,500 out of 21,800 secondary schools will also have science of an elective standard. The completion of this programme is expected to provide a more satisfactory foundation than at present for the further expansion of science education at the university stage during the Third and subsequent Plan periods. A number of supporting measures are also proposed to be taken to improve and strengthen the teaching of science. The existing science syllabi in force in different States will be reviewed and modified where necessary with a view to integrating them with the science syllabi at the earlier and later stages of education. A programme of preparation of teachers' handbooks, students' manuals, science textbooks and supplementary reading material in science will also be undertaken. The present shortage of science teachers will be made up to as large an extent as possible by increasing facilities of science education at the university stage and by providing various types of in-service training in content and methodology for the existing science teachers. The training of laboratory assistants in the techniques of handling laboratory apparatus will also be taken up during this period. In addition steps will be taken to standardise designs of science apparatus and to get them manufactured in the country itself. In order to coordinate, guide and direct the entire programme of science teaching as well as the training of key personnel, a central organisation for science education is proposed to be set up in the Third Plan. A scheme of science talent search is to be introduced with a view to identifying promising talent at the secondary stage and providing opportunities for its development." (pp. 585-586).

The above extracts indicate the policy decisions and certain action-points for the Central and State Governments though it may be stated now that in the Second Plan not much was done regarding science education in schools. In the Third Plan while some steps are being taken the main idea has caught the imagination of all concerned and that is the first step towards formulation of a programme and further implementation of it. A big programme with adequate financial resources will have to be

considered by the States and the Centre for the Fourth and the successive Plans.

3.04. We are aware that school authorities, Education Departments of State Governments, the Central Ministry of Education and the Planning Commission have all expressed keenness about improving the content of science education in the schools and if necessary, reorganising the courses. We are also aware that encouragement is being given to manufacture scientific instruments and apparatus in India and steps are being taken by the Ministry of Education in regard to the scheme for science talent search.

3.05. However, we find that the pace of progress is slow and difficulties were mentioned to us in relation to the following points :

(1) Difficulties created by structural changes in secondary education;

(2) Improvement of curriculum and syllabus of science subjects including Mathematics at the different school stages;

(3) Difficulties in securing science teachers;

(4) Difficulties of adequate laboratory equipment and apparatus;

(5) Lack of suitable textbooks in different scientific subjects;

(6) Early specialization.

1. *Difficulties created by structural changes in secondary education*

3.06. In our discussions, our attention was drawn to the difficulties created by structural changes in secondary education. We understand that the problem is being considered by different State Governments and the Ministry of Education. But certain recent thinking has made the problem singularly important, as the whole question of introduction of science courses at different levels of schooling is linked up with the structure of secondary education.

3.07. Historically, the Saddler Commission in 1919 and the University Education Commission in 1949, recommended that there should be a three-year degree course after 12 years of schooling. The Secondary Education Commission had recommended a slightly varied pattern of 11 years of higher secondary education, but the evidence of the Sampurnanand Committee and others, especially the recent decision of Madras Government and the practice in U.P., Kerala, Andhra, Orissa, Gujarat and Maharashtra indicates modification to this pattern. The 12 years of schooling should have 2 stages or 3 stages, but there should be a stage after 10 years of schooling when students are able to go to trade schools, polytechnics, defence and railway services etc, and various other occupations according to their aptitude. This will not necessitate students spending one more year in a higher secondary school or 2 more years for the intermediate course. One clear suggestion which we have received from a senior Member of Parliament, who knows educational development very well is : "I am of opinion that we should say clearly and definitely that we believe in the introduction of a 12-year course prior to admission to the University for three-year degree course The breakup of secondary plus primary education should be 5+3+2+2 or some other plan which may be separately considered." But during the next 15 years a proper direction has to be given to this pattern so that prescription of syllabus in science and other courses at different stages could be facilitated and migration of students from one State to another will not have many difficulties of placement in proper schools which they face today.

3.08. Another distinguished Member of our Committee, who is a scientist and educationist has said "the best course would be to have 8+2+2 as the pattern of school education. Elective science can then be taught in the 11th and 12th classes. So long as there are 11-year schools of Higher Secondary, the teaching of elective science has to begin at least from the 10th class." This apparently is not conducive to preparation of science students for further studies and research.

3.09. Another expert in science education expresses his view in the following way : "In fact, considering that the realistic view of prospects of radically improving the quality and content of school education is not very high, it could be best in the interest

of science in the country to take the pupil out of the school as early as possible *viz.*, at the X grade stage. As we succeed in diverting more competence and resources into the schools, we might upgrade them one by one. A fair way of providing for this is to get each school subject examined in the secondary examination at two levels—ordinary which represents standard of Class X and advanced which represents higher standard." It will be observed from this extract that the writer has been thinking of the British pattern where the advanced level is taken in VI form in a course between the ages of 16-18 in a minimum period of two years but many do it in three years. The ordinary level is finished earlier comparable with our X class.

3.10. The Sampurnanand Committee appointed by the Government of India in the Ministry of Education on emotional integration in 1962 have published their report and they were seized of the same problem. They have said in their report* that "a common organisational pattern that is so necessary for a national system of education has not been evolved so far." They have pointed out that at the elementary stage there are schools with 7 years' courses and also 8 years' courses. The age of admission to class I is 5 in some States and 6 in many others. The duration of secondary stage varies from 2 years to 4 years. They say : "We consider that in the overall interest of our student population to whom education, apart from its training for citizenship, is also means to gainful employment, there should be a common pattern of education in the country which will minimise the present confusion and coordinate and maintain standards. The need for a common pattern of education has not, however, implied a uniform sameness in the syllabus for schools all over the country. Variations within a broadly accepted framework would naturally occur and much would depend on the teacher and on his interpretation of syllabus .... Differences in educational patterns and standards also cause considerable inconvenience to students migrating from State to State." They have recommended a re-examination of the present pattern of education that has already taken place and they have indicated that such an examination should measure the impact of expansion and the gravity of wastage.

*Chapter IV, "General and Major Policy Suggestions".

3 11. We have considered this and from the point of view of science education in the schools, we feel that unless structure is uniform, stages at which science courses should be introduced, with the gradually rising content of knowledge and practical experiments, cannot be easily visualised to apply to all parts of the country.

3.12. Our attention has also been drawn to a valuable recommendation made by the Sampurnanand Committee that "there should be more terminal stages in the pattern of Secondary Education which should be planned in a comprehensive manner, recognising (a) that education should be provided for different types of aptitudes and abilities, (b) that pupils should be branched off at different terminal stages to enter different walks of life, and (c) that at the terminal stages, there should be provision for vocational and semi-vocational training for those who leave school."

It will be seen that the principles contained in the recommendations made above are consistent with the present economic conditions of the country and imply introduction of science courses at different stages in relation to the preparation of the students for later vocations or courses of training and further education they would like to undertake.

3.13. The Sampurnanand Committee have indicated that the two-year unit after 10-year high school may be attached to the high school where it may be called the higher secondary class or it may be attached to degree college as pre-university classes. "It can also be an independent unit and may be called Junior College. Such junior colleges can be controlled and recognised by the State Education Department or the university or both. Students who successfully complete the higher secondary, pre-university or junior college courses may be awarded a diploma to qualify them to different avenues of employment available to them."

3.14. A point made by the Committee is that such an arrangement may not prove to be too expensive because when the 10th class in the high school stage will be a stage for diversification the number of students entering the junior college or the higher secondary class was likely to be much less than the number that

might enter the 11th class if that were the only terminal stage in secondary education. Similarly, when the junior college becomes a useful terminal stage, the indiscriminate rush to universities may by stemmed and more places in colleges released for those best fitted for higher education. However, there will be larger cost for providing training courses for technicians, craftsmen and others who would follow different vocations after the 10th class but surely proper manpower planning should take care of it in the Fourth and successive Plans.

2. *Improvement of curriculum and syllabus of science subjects including mathematics and different school stages*

3.15. Because of the position stated above and the lack of uniformity of the pattern of secondary education, it has been brought to our notice that the contents in syllabus also vary from State to State. Appendix XVI in the Sampurnanand Committee's report analyses the system of school classes in India as obtained in 1960-61. We have been told that the courses of science as well as other subjects have alarming differences in the States and it is desirable that there should be uniformity of courses and class structure in all the States so that textbooks also could be written in the same way for all the States particularly in the science subjects and lakhs of copies in different languages could be made available covering uniform syllabus. This does not leave out scope for experimentation and initiative of the teachers in different States and in different types of schools.

3.16. An attempt was made in 1957 by the All India Council of Secondary Education to prepare a draft syllabus for the higher secondary schools, but our examination of the syllabus has revealed that particularly in Southern States which appointed their own committees for reorganisation and recommended different patterns of syllabus, the draft syllabus appears to have been ignored. The purpose of a uniform draft syllabus has not served for all the States of the Union.

3.17 Besides, some modernisation in school curriculum has to be brought in on the basis of courses introduced in some of the advanced countries such as the U.K., U.S A , U.S.S.R., France, Germany and Japan. But modernisation of school curriculum is a complicated problem and in all State Boards and State

Governments the difficulties arise on account of a tension between the pull of the past and the urge for the future. Sometimes the tradition dominates too much and the ideal or progressive position thought of by some experts suffers from not being accepted as practicable. We, therefore, recommend a programme of action in chapter IV

3. *Difficulties in securing science teachers*

3.18. The position explained to us was that there have been difficulties in securing good science teachers in the higher secondary schools as well as high schools. It seems to us that for a long time to come we have to be content with qualified teachers for science rather than trained teachers. By a qualified teacher is meant one who has got a degree of B Sc. or preferably M.Sc. in science with specialisation in physics or chemistry or biological sciences. To secure teachers with these qualifications and additional training qualifications would be difficult. Pedagogical training in higher classes where subject teachers are required is, no doubt, useful, but the emphasis has to be on teachers who have the knowledge of the subjects which they can impart to the students with the normal aids and laboratory and library equipment. In classes IX to XII subject teachers would be necessary. A good science graduate has many demands on him in a developing economy, and the problem of scarcity of science teachers is serious in other countries also such as Cananda, U.K. and U.S A. for the same reason. Our attention was drawn to an address of Dr Glen Seaborg, Chairman of the U.S. Atomic Energy Commission, April 14, 1962 from which a relevant extract is given below :

> "Certainly I agree that teachers need professional course work such as that which shows how children and adolescents learn, grow, and develop. Supervised practice teaching is also very important. The system becomes too inflexible, however, when credential requirements begin to dictate the courses universities and colleges must teach, the units of credit to be given, and overstress formal 'education' courses to the detriment of subject matter courses. Educational institutions then lose the initiative and freedom to experiment and develop excellence in their teacher education programmes.

The system tends to result in inadequate subject matter preparation for those who elect to work for credentials based primarily on 'education' courses. Simultaneously, it discourages from entering the teaching profession those individuals who excel in particular academic fields but have not concentrated on 'education' credits. I suggest that the individual who is well-trained and loves his subject, and who has a drive to communicate his knowledge and interest to others, makes the best teacher.

The more advanced the grade, the more important it is for the teacher to have good training specifically in his particular subject fields. Thus, it is far more important for the high school teacher to have been trained in academic disciplines than to have been trained in methodology. And when we come to the level of the junior college, I can see no justification for any emphasis whatever on 'methods' courses. Undoubtedly, credential requirements for junior college teachers could be greatly diminished. Fortunately, there is now an increasing recognition of the need for establishing a better balance between education matter courses and subject matter courses. Another interesting and desirable trend is the movement for 'teacher colleges' to provide broader and more comprehensive arts and science curricula rather than the narrower education curricula.

Another important aspect of teacher training relates to the need to keep experienced teachers abreast of the latest developments in the subject matter that they are teaching. Therefore, a very pertinent question faced by all boards of education is how to provide and to finance methods to accomplish this goal. It is to this point that one of the major efforts of the Federal Government in science education is addressed—namely, the various faculty institute programmes of the National Science Foundation, with the cooperation in specific areas of other governmental agencies including the Atomic Energy Commission."

4. *Difficulties of adequate laboratory equipment and apparatus*

3.19. Along with difficulties of securing science teachers, complaints were made that laboratory equipment and apparatus

is not either sanctioned in schools according to some standard or where it is sanctioned, there are difficulties in securing this Our attention has been drawn to the discussion of this problem in the report printed in the *South Indian Teacher* in February, 1962, by the South Indian Teachers' Union, which has been considered in the next chapter.

3.20. The following extract from Dr. D. S. Kothari's address at Udaipur in 1961 is also relevant:

> For the expansion of science education in our country, it is very important to develop simple apparatus and equipment of good instructional value This is an important and urgent task. Sections, or even divisions, for this purpose could with profit be established in some of the National Laboratories and university departments.
>
> Every high school should be provided with a reasonably good workshop, say carpentry tools, simple mechanics' kit, and possibly a manual lathe. Teachers and students should be encouraged to build simple apparatus in the school workshop. One learns a lot of good science by using a simple and inexpensive apparatus to the limit of its capability and accuracy. On the other hand, one hardly learns little of real value by using a first-rate instrument in a third-rate way, as unfortunately is very often the case in our laboratories.
>
> In the case of school buildings, it should be possible to improve effectively their fundamental utility and at the same time cut down costs. Much thought has been given to this subject in recent years. For example, see: Ministry of Education (UK), *The Story of Post War School Building*, Pamphlet No. 33. (HMSO 1957).

5. *Lack of suitable textbooks in different scientific subjects*

3.21. The position of the textbooks in the country has been brought out very well by Dr. D. S. Kothari in his address, quoted above. The following extract is significant:

> The question of textbooks is the most important and urgent one for our country. Energetic action, on State and national basis, is required to progress the preparation of high quality school textbooks.

In this task we can take real help from some of the excellent textbooks that have recently been prepared (particularly in the United States and the U.S.S.R.), for example, the textbook on physics for secondary schools prepared by the Physical Science Study Committee (U.S A) under a grant from the National Science Foundation and also the Ford Foundation. The Committee consists of a group of university and secondary school physics teachers including some names internationally known for their contribution to research in physics. The school textbook apart from the fundamentals of classical physics also describes in simple language elementary ideas about atomic energy, wave mechanics and so on. The book opens with the statement: 'Physics is the fundamental science of the Natural World. It tells us what we know about that world, how men and women found out what we know, and how they are finding out more today', and it concludes with the paragraph: 'We have, therefore come to the threshold of many new developments. In the years since 1925 (when wave mechanics was formally stated) wave mechanics has given us a great deal of understanding of the physics that was previously mysterious. There is much to be studied in these new fields, some of it already fairly well understood and a great deal of it the subject of the present work. This book is barely an introduction. A life can be well spent in a study of the physical world.'

A new textbook on high school chemistry was prepared (under the auspices of the great chemist G. T. Seaborg, now Chairman of the U.S. Atomic Energy Commission) by nine college and university professors and nine high school teachers in a period of six weeks 'The high school teachers kept the college and university professors down to earth and the latter helped to raise the sights of the professional teachers. It was a mutually beneficial experience and this has been true of similar task forces in the other scientific disciplines.' Of particular importance are the following observations of Seaborg.*

"I turn now to a discussion of what seem to me to be four definite trends towards improvement of science teaching

*At the annual banquet of the National Science Teacher's Association, March 27, 1961.

in the secondary schools. They are : One—improving the course content; two—new emphasis on laboratory work; three —scaling up teacher training and standards; fourth—breaking down of barriers that for too long have cast the professional scientist and the professional teacher in the role of antagonists instead of collaborators."

6. *Early specialisation*

3.22. A view has been strongly expressed by scientists and educationists that "at the stage of school education specialisation should be avoided, as far as possible. The bulk of the course should be common to all students. One of the serious defects of the present higher secondary school system in our country is that it requires the student, hardly 13 years of age, to decide about the subjects he would later take up at the university."*

In certain States like Madras, there are comprehensive courses. But where higher secondary schools have been started there is a course of general science in lower classes, and later specialisation in science subjects or in elective science. In many States, where the higher secondary school education system has been introduced, the students take a public examination at the end of the X class which is equivalent to matriculation and also such students who do not go to the PUC (pre-university course) classes in the colleges but are admitted to the XI class of the higher secondary schools take another examination, where the elective courses in science are introduced This creates difficulties for the course which is very often half of what was planned for a two-year course of Intermediate science examination and appears like a truncated system.

3.23. In the U.K. it is now considered essential that all pupils should follow a balanced course in science subjects up to the end of 5th form. In the policy statement in Science and Education in 1961, published by the Science Masters Association of U.K., it has been stated that "there should in fact be no division into science specialists and arts specialists until beyond this level, so that specialisation in arts or sciences, or even a

*Address by Dr. D. S Kothari, op *cit*

combination of the two, may be available to all pupils of the necessary ability when they enter the sixth form." The fifth form in the U.K. is equivalent to our X class or matriculation standard. This is because the student leaves in the U.K the primary school at 11. Then there are five forms up to the age of 16 giving him general education. The sixth form qualifies a student to go to the universities and students spend at least two years but quite often three years in this class for completing the course of the G C.E. advanced level along with ordinary level. In order to be able to qualify himself for admission to the university, he has to complete two subjects at the advanced level (A level) and three subjects (O level) as a minimum, though good many students take up more than two at the advanced level to ensure admission in the universities.

3.24. The implication of the above, when applied to conditions in India, would be that courses in arts and science should not be divided up to the X class and certain options should be made available in the XI or XII classes later. But specialisation should be postponed as far as possible.

3.25. In the U.S.S.R., all students whether they take up science courses or other courses later are compulsorily asked to study a considerable amount of mathematics, physics and mechanics. Every student in the U.S.S.R. in his final year at school—and the course is from the age 7 to 18—covers such topics as atomic structure, artificial radioactivity, energy released in nuclear reactions, cosmic rays, nuclear power stations, use of radioactive isotopes in agricultural industry and so on. This is a significant point for those who have to formulate curriculum structure and detailed syllabus for the school classes.

Chapter IV

EXAMINATION OF DOCUMENTS AND DATA

Method and approach

4.01. As stated earlier, our main effort has been to examine the present position of science education in schools from the point of view of the knowledge of some of the experts and advice of the Ministries. Some of us were familiar with the problems and certain documents were made available to us which have considered these problems. Among the various studies and publications placed before us and the data collected by the officers of the Ministry of Education and Planning Commission, we were able to sift and select a few. Among these are (1) "The Report of the Sampurnanand Committee on Emotional Integration, Ministry of Education 1962", (2) "Position of Science Teaching in Indian Schools : A Factual Report 1963". This is a publication of the material prepared for the first meeting of the Science Committee appointed by the National Council of Educational Research and Training under the Chairmanship of Professor P. C. Mahalanobis. This gives the position of science education in schools as it obtains in various States in the country. It is prefaced by two papers by Prof. Mahalanobis on (i) Social Transformation for National Development and (ii) Scientific Basis of Economic Development and an address by Dr. D. S. Kothari, Chairman, University Grants Commission on Some Aspects of Secondary Science Education which he delivered at Udaipur at the Fourth Annual Conference of All India Science Teachers' Association in December 1961, (3) "An Enquiry into the Conditions of Teaching Science in Secondary Schools", a study taken up by the South Indian Teachers' Union, Madras, and published in *South Indian Teacher* in February 1962, (4) "Educational Studies and Investigations"—Vol. I : A Publication of the National Council of Educational Research and Training 1962, which contains a Chapter on "Teaching of

General Science in Secondary Schools" published by the All India Council for Secondary Education, Ministry of Education 1957, (5) "State Textbook Production in India" published by the Central Bureau of Textbook Research, Ministry of Education 1959, and its revised edition 1963, (6) "Education in the Soviet Union" by Raja Roy Singh, Ministry of Education, 1962. Among the foreign documents we have particularly selected (a) the "15 to 18—Report of the Central Advisory Council for Education", England (Crowther report) 1960, (b) "Rethinking Science Education, being the 59th Year-book of the National Society for the Study of Education, Part 1, 1960, (c) "A Programme to Improve Science Teaching Steps", publication of U.S. Office of Education, Washington, 1962, (d) "Science in Primary Schools", by Ministry of Education, Pamphlet No. 42, London, HMSO, 1961, (e) "Science in Secondary Schools" by Ministry of Education, Pamphlet No. 38, London, HMSO, 1960.

4.02. Besides these, our attention was drawn to other documents, among which we may mention (1) "UNESCO Source Book for Science Teaching 1956", (2) "Science in Schools"—Proceedings of a Conference under the auspices of the British Association for Advancement of Science, 1958, (3) "Teaching of Science in Post-Primary Schools" by E. J. Searle : Publication of the New Zealand Council for Educational Research 1958, (4) "Secondary Modern Science Teaching", Part I & II : Report on the Teaching of Science in Secondary Model Schools prepared by the Secondary Model Schools sub-committee of the Science Masters' Association, 1957. These are only a selected number which have influenced our thinking. There are, no doubt, many other valuable documents and factual data on the subject with which experts are familiar. We discuss below the main points in some of these publications bearing on our subject.

(1) *Sampurnanand Committee on Emotional Integration*

4.03 This valuable document, from which we have quoted earlier, makes recommendations not only about the various factors affecting our country in respect of the distressing frequency with which disruptive tendencies were making themselves felt

in the country, but also about the role of education in counteracting such trends and fostering unity. An important point in the report is the examination of the role of education in promoting the process of emotional integration in national life. They have indicated educational programmes for youth in general and of students in schools and colleges in particular to strengthen in them the process of emotional integration. Chapter IV of the report deals with general and major policy suggestions and recommends that a common pattern of education which does not exist at present must be established. We were struck with what the Sampurnanand Committee say about the periodical discussions taking place between the Government of India and the State Governments at various levels for implementing educational programmes :

> "It is common knowledge that we have not succeeded during the last 15 years in evolving a national system of education. Many policies suggested by the Centre to the State Governments have not been implemented. Modifications and amendments have been made at the stage of implementation to many other policies suggested. Most of the policies and programmes suggested on the recommendations of the numerous committees and commissions appointed by the Government of India from time to time since independence remain unimplemented for one reason or the other. It would appear, therefore, that neither at the Centre nor in the States there has been a proper co-relation of the policies enunciated and the programmes taken up for implementation. Neither the Centre nor the State Governments are satisfied with the present position. The State Governments naturally are aware of their own educational problems and are critical of the manner in which their proposals are modified or amended by the Centre. It is felt that such amendments are often made more on financial rather than on educational grounds. The Centre on the other hand feels that its advice and help to the States is not fully appreciated. We cannot escape the conclusion, therefore, that the function of policy making and finalising of programmes to implement such policies has not received adequate attention during these 15 years".

4.04. It will be seen that this position is partly responsible for the varying types of programmes of science teaching in the schools of the several states.

4.05. The recommendation of the Sampurnanad Committee about the common pattern of education in the States has already been mentioned in the earlier chapter. Their emphasis on the need for more terminal stages in the pattern of secondary education has been noticed by us.

4.06. The Sampurnanand Committee has a chaptered on curriculum for the emotional integration of the pupils but incidentally has made many suggestions for further research in a field which is most complex for all educationists. They have indicated that the over-loading of the curriculum in number and content of subjects should be examined at all stages of school study and we felt that science education in the curriculum has to be examined in relation to this suggestion. They have indicated that it would be necessary to work out detailed curricula for all stages and details of syllabi of different subjects in the curricula have to be worked out by expert committees. They have also mentioned that dynamic methods of dealing with topics of syllabus have to be evolved and have recommended that "an efficient and well staffed curriculum research unit should be set up in each State and a separate unit at the Centre, under the National Council of Educational Research and Training. These units should work in close cooperation with textbook bureaus and teacher training colleges and results of their research should form the basis of curriculum construction and criteria for textbooks". We endorse this recommendation.

4.07. The chapter on textbooks and other reading materials similarly is a significant contribution to the subject and we would commend their recommendations in regard to production of textbooks in different subjects, particularly in science subjects on an all-India basis. They have recommended that the Central Government should be responsible for the effective coordination of the activities of the State Governments in the field of textbook production and the Central Bureau of Textbook Research, functioning under the National Council of Educational Research

and Training should take up the work of content analysis of textbooks and suggest methods of improvement. We endorse his recommendation, particularly in respect of textbooks in science subjects.

4.08. We have also seen appendix XVI of the Sampurnanand Committee report where the system of school classes in India (1960-62) is given and we would like the Central and State Governments to evolve a uniform policy in this respect, so that there will be not only uniformity of science teaching in all schools so far as frame work is concerned, but students migrating from one State to another will not find many diffiulties as they do today in respect of changes in the content of courses, in the different classes.

(2) *Position of Science Teaching in Indian Schools—A Factual Report*

4.09. This publication is preliminary to the work of the Standing Committee under the Chairmanship of Prof. P. C. Mahalanobis appointed by the National Council of Educational Research and Training. The question of scientific base for economic development has been discussed here in Chapter II by Prof. Mahalanobis and important suggestions have been made about science education and research. It emphasises all the more the strengthening of our science courses in the schools. The various aspects of Secondary Science education discussed in the address of Dr. Kothari have been referred to in the earlier chapter. We consider this analysis in respect of the problem of numbers of schools, curriculum, the danger of early specialisation, participation of school teachers and students in college-university work, important to develop simple science apparatus and equipment of field instruction and the need to strengthen teaching profession, as one on which the Central and the State Governments will, no doubt, ponder and formulate policies for action.

4.10. The analysis of science teaching in schools is a bare statement of facts and it is seen that the percentage of time allotted to science in the school time-table at different stages mentioned on page 37 of the report indicates that the variations

are so great that it is high time that a uniformity of syllabus and science content in the courses is brought about as early as possible. The sections on laboratory equipment, cost, teachers and textbooks are very significant in each State and this has helped us to make certain suggestions in the next chapter.

(3) *An Enquiry into the Conditions of Teaching Science in Secondary Schools*

4.11. This is an analytical study taken by the South Indian Teachers' Union and we wish that the methods adopted for the study are used for similar studies in other States. They examined 171 schools run by different agencies in the 13 districts of Madras State. They also collected evidence from 518 science teachers and 177 heads of institutions scattered all over the State.

4.12. The primary aim of this report was to evaluate the facilities offered for science teaching and find out the extent to which they meet the demands of science syllabus in the reorganised scheme of secondary education in terms of space, equipment, services, learning aids, teacher equipment and teaching load. The report thus becomes a most valuable document. The summary of their findings is given below :

1. From a study of the conditions of teaching science in secondary schools of strength ranging from 57 to 1,282 in the high school department alone, we learn that there is a great need for improving laboratory space, fittings, fixtures, apparatus and appliances, materials and chemicals, to facilitate effective science teaching.

2. There is an inadequate recognition of the value of visits which show science in action.

3. Nearly 40 per cent of the schools under reveiw do not possess audio-visual aids. Even where they are used, there is no adequate previous preparation for observation and useful follow-up work for reinforcing the ideas gained.

4. In the teaching of biology, there is no noticeable stress on the place of garden and acquarium.

5. Museums, where they are kept, show no fresh additions. In a good number of schools it is not regarded as an indispensable aid to teaching.

6. In the absence of facilities for individual or group work in the laboratory, frequent teacher demonstrations are indispensable for instilling facts and principles of science. In a large majority of schools even those demonstrations are not adequate in number. Learning science by doing in the present circumstances has become more an exception than the rule.

7. Where there is evidence of experimenting by individuals or groups, there is no insistence on the maintenance of records.

8. Lack of money is the root cause for many of the deficiencies in school equipment for teaching science.

9. Science teachers can to a greater extent than now, harness agencies, such as extension services and science clubs to improve teaching of science.

10. The competence of science teachers of middle school standards has to be increased so that the entrants to the eighth standard may have adequate preparation for high school science work.

11. To put the matter in a nutshell, high schools are having qualified science teachers but they lack the tools of instruction. The situation requires the immediate attention of all those interested in the promotion of science education in secondary schools.

12. Science teachers lack confidence to handle elements of those branches of science which they did not study for their degrees.

(4) *Teaching of General Science in Secondary Schools of Orissa*

4.13. Teaching of general science in the secondary schools of Orissa has been printed in Educational Studies and Investigations, Volume I, of the National Council of Educational Research and Training and is a summary report of the first phase of a research project on the teaching of General Science completed by the Bureau of Educational Research, Radhanath Training College, Cuttack. This study was undertaken on the

questionnaire methods and the investigation was about determining the present state of affairs with regard to the teaching of science in secondary schools of Orissa. It is useful from the point of view of opinion of teachers and inspectors regarding the defects of the present system and methods of improvement.

The findings of the report indicate that in secondary schools, it is necessary to break up the different branches of science as physics, chemistry, biology, etc., and taught separately by specialists in the subjects. Secondly, the syllabus should contain an emphasis on application of science and experiments and laboratories need to be improved for that purpose. They also mention that equipment, buildings and textbooks need to be improved very much and indicate that more money should be made available to provide good laboratories with adequate apparatus, more audio-visual aids, science books for the library and funds for taking students out for excursions. The need to provide botanical gardens has been emphasised and a suggestion is made regarding decreasing the load of the science teachers and their proper training.

(5) *Draft Syllabus for Higher Secondary Schools of All India Council of Secondary Education*, 1957

4.14. This syllabus was drawn up by experts at the Centre but from our enquiry we found that it has not been adopted by States or many variations have been introduced where reorganisation of courses has been introduced. The problem, therefore, has to be reconsidered in the light of the changing conditions of today.

(6) *State Textbook Production in India*, 1959

4.15. This is a survey of the existing practices in the States in textbook production. The problem of nationalisation of textbooks along with the scope that private enterprise should get has been analysed in a factual way in the different States. Part III of the survey deals with the textbook production abroad which is very informative. We think that the information given about textbook production in the USA (California), New Zealand and the USSR is very valuable and the method adopted in this survey and the results stated should give an indication of the efforts that have to

be made in this direction by the State Governments. The revised edition of 1963 brings the data up to date regarding the nature and extent of State participation in the selection, production and distribution of textbooks and also on the composition and function of textbook committee, etc.

(7) "*Education in the Soviet Union*," 1962

4.16. This is a report, by Raja Roy Singh, of the visit of the Indian Delegation to the USSR. It discusses the system of education and the school curriculum in the Soviet schools, among various other important questions of Soviet education. Besides, it contains useful information on the examination system, textbooks and other educational literature and the role of science in the school system.

4.17. We had before us a good deal of material about the problem of science education in some of the advanced countries. We should mention only a few important ones which should help us in thinking over the course of action to be adopted.

4.18. (a) *The Crowther Report of the Central Advisory Council for Education, England, Volume I* (1962) deals with the problem of school education mostly at the sixth form stage in U.K. in relation to the changing social and industrial needs of the society and the needs of the individual citizens. The education of the boys and girls between 15 to 18, and in particular, the plans at various levels of general and specialised studies between these ages and the inter-relationship of the various stages of education have been examined in the report.

Part 5 of the report deals with what is known as the sixth form which is equivalent to our Intermediate course. It contains an assessment of the course which is the remarkable development of the sixth form since the war and also considers the closely interwoven problems of specialisation and university entrance. The question of early specialisation is considered in Chapter 25 and it sets out some of the general principles about the curriculum of the sixth form in U.K. which is of great value to us. They have stated that "periodical revisions of the intellectual diet are in fact necessary" The argument set out by them for an element of specialisation after 15 or 16 in the sixth form would help us to

draw a proper curriculum in the XI or XII classes of our educational system. They have also explained that school education has to be an instrument of liberal education, but they say "until syllabuses have been revised with this purpose in mind and are no longer regarded simply as the first stages in the vocational training of a scientific worker, it is impossible not to endorse many of the current criticisms of the ill-results of over-specialisation."*

4.19. (b) *Role of Science Education, in the 59th year book of the National Society for the Study of Education,* discusses, among other problems, the question of role of science in our culture and points out that although much of the modern science is of comparatively recent origin, its practical aspects have had far-reaching impact upon our culture. "Unfortunately science is too frequently viewed only in this light. Its purely speculative nature, whereby creative imagination of man seeks unity amid the great variety of nature, is not so well understood. When viewed in this light, Science becomes less antagonistic of the other ways by means of the order in the world. It is through science that man seeks to understand this order by self-correcting methods that put limiting values with his preconceptions." (pp. 16-17). Some of the most important chapters written by outstanding authorities are: Science Education for the Changing Times, Status of Science Teaching in Elementary and Secondary Schools, Teaching of Science in Elementary Schools, Improving Secondary School Science, Organisation and Administration for Curriculum Development in Science and the Education of the Science Teacher. We consider this book as a most valuable document for those who would think ahead in the formulation of policies in respect of science courses in our schools.

4.20. (c) *Programme to Improve Science Teaching*—a publication of the Office of the Education, USA, in which they have stated that three purposes seem to have motivated the Congress to improve science teaching in the interest of national welfare and security:

(i) to ensure a continuing flow of excellent young people into the scientific manpower pool of future,

(ii) to establish a level of scientific literacy among all citizens that will help them to live effectively in our

* Page 265, para 393.

modern cutlure and will maintain a climate of opinion favourable to the scientific endeavour; and

(iii) the development and apprehension of science as humanistic pursuit and an understanding of its relation to other equally important disciplines.

They have suggested 7 steps to carry out a programme within the States of the USA to demonstrate how local and State agencies and the U S. Office of Education can work cooperatively; secondly, how the available resources can be identified and used; and thirdly, how local leadership and initiative can be stimulated to constructive action for a continuing programme to improve science teaching

4.21. The first step, they say, is that of initial planning between the State Department of Education and the Central Office of Education. The second is to plan at the local level the means discussing the evidence of need for improving science programme, reviewing the action leading up to this purpose and looking at the entire programme as a whole through the conference. The third step is assessment at local level of personnel and the available resources. The fourth step is a plan for action through the local and State Department of Education, addressing themselves to both immediate and local range for improving the science programme and a follow-up programme by local personnel strength. Step 5 is to take action on an agreed plan, using the new curriculum materials prepared by the State or local committees, expanding in-service education programmes and increasing the use of resources available from industry and other community resources. Step 6 is evaluating the project by local personnel with the help of the services of State experts and the Central Office of Education. Step 7 is to disseminate the reports of evaluation with a view to creating public opinion for the purpose of improving science education and teaching.

We consider these as useful suggestions for a course of action by the State Governments and the Centre.

4.22. (d) *Science in Primary Schools* : *U.K. Ministry of Education Publication*, 1961—This pamphlet is meant to encourage the interest of science teaching and give it coherence and direction

in account of the growing interest in the part science could or hould play in the education of young children. It is primarily iddressed to teachers, on whose ideas and decisions successful levelopment must depend The pamphlet indicates some lines of levelopment suggesting, for example, organisation of practical work in relation to varied abilities of students, use of problem tables and enquiries involving measurement. It also emphasises the place of books and apparatus even in primary schools The argument in the pamphlet is "that the pursuit of science is no more than a natural extension of a process already developed in other environmental studies and even keeping with children's interests sometimes their dominating interests" Further, "it makes a special contribution by directing attention to the immediate environment, accessible through close observation and experiment, as a source of information. Using familiar material, well within their compass, the children take first step towards an understanding of scientific method and in so doing gain experience of a discipline, capable of much wider application."

4.23. (e) *Science in Secondary Schools: U.K. Ministry of Education, Pamphlet No.* 38, *London*, 1960—The pamphlet surveys the teaching of science in the British Secondary Schools and analyses the purposes which should inspire it and suggest practical measures for carrying out its purposes. This has been done because of the demand for more attention being paid to science. In the first place, it has been stated that early specialisation carried to experiments has little to commend it; at best it is but a necessary evil. It indicates that it is particularly a duty of education authorities to keep the studies of the students in early years broad. Secondly, it deals with the problem of scientific education of the non-specialists in secondary schools. What is required is a scientific approach. "Admittedly, there is little in the scientific method which is peculiarly characteristic of science itself; a careful sifting of observations, the designing of experiments to test ideas and the habit of strict intellectual honesty are the virtues which are needed in many other studies as well as science."

4 24. They have recommended that at the elementary stages the courses arranged for the future specialists should not be different from those for others. All should undertake a simple empirical study of the silent phenomena which incidentally will

be much more valuable to the future scientists than any superficial attempt to begin specialisation work before pupils are old enough to und rstand it. For the age group up to 16, they have indicated lines of general science. From 16 to 18, advanced courses in the subject might well begin and for majority of pupils, this will mean a break-up from the elementary course which should last up to the age of 15 plus. For students beyond the age of 18, "the suggestions imply that as a rule, no pupil will need to face more than one external examination in science while at school and that when such an examination is taken it could occur at the near end of this course." There is also discussion of the training of teacher in science and it has been stated that men with experience and knowledge of science are required for teaching science courses.

CHAPTER V

FUTURE DEVELOPMENT AND SUGGESTIONS

5.01. From the preceding chapters it will be seen that there appear to be many difficulties in implementing various suggestions made in the report of the Third Five Year Plan at page 586 about improvement of science education in secondary schools. This would also seem to imply that science education at the university stage would be affected by the weaknesses found in the foundation courses at the school stage. We feel, therefore, that steps have to be taken to improve science education in the schools and the defects mentioned in the Madras report and the Orissa survey have to be borne in mind while suggesting a course of action. We also feel that it is desirable that every State Government should undertake a survey of science education, curriculum, syllabus, textbooks, teachers, equipment, etc., and on the basis of facts collected and difficulties of the State Governments which could be analysed, a programme of action more or less on the lines of the 7 steps suggested by the U.S. Government mentioned in Chapter IV should be organised by State Governments with the cooperation of the Central Ministry of Education and the National Council of Educational Research and Training.

5.02. We should mention here the importance of the programmes of the National Council of Educational Research and Training organised as an autonomous unit since 1961 under the Ministry of Education. We have been told that its programmes are designed with focus on research studies and investigations in problems of education and they select those problems for study which would make a direct contribution to the improvement of schools, training of teachers, provision of extension services to the schools and dissemination of information of improved school practices. The Council is at present engaged in a programme of production of textbooks for secondary schools and other educational literature in different subjects. Their advice will he most helpful in arriving at a policy of improving science education in

the schools, but every State must first analyse its difficulties and suggest lines of action for improving the position

5.03. We have recognised that it is the duty of all schools under the administration of the State Governments to present science as a part of the cultural and humanistic studies. In planning future programmes it would be desirable, therefore, that State Governments, the Central Government and their different bodies like the National Council and the Planning Commission should work out practical programmes of action It seems to us that almost every State—we have mentioned Madras and Orissa, but we are told that the same is the position in other States—has to face financial difficulties in establishing suitable laboratories, science museums, science clubs and libraries. We feel that it should not be difficult for the Central Ministry of Education in cooperation with the State Governments to analyse this problem in detail and to arrive at calculations of requirements of financial provision so that in the remaining years of the Third Plan and particularly the Fourth and subsequent Plans it should be possible for the Planning Commission to make suitable provision in the State plans for improvement of science education at the school level. Everyone is conscious of the importance of such a step and no one would disagree that every attempt is made to encourage science courses in the school syllabus in full recognition of the fact that such courses taught should be in harmony and coordination with and not in opposition to the other traditional subjects.

5 04. Recognising this need for emphasis on science teaching in the schools in modern times particularly in an age of scientific and technological development and recognising also the fact that in all advanced countries courses of studies at the school level emphasise science as a major human activity, as a means to discover truth about nature and realising also that basic values in modern life are a deep concern of scientific education, we further recommended that the State Governments should see to it that a proper machinery is set up immediately for organising new science syllabus in the curriculum of school courses in cooperation with the Central Ministry of Education and their various advisory and research bodies

5.05. We are apprehensive of what the Sampurnanand Committee has said about lack of uniformity of courses in States at the secondary education level. We think that the Sampurnanand Committee's report should be considered by all State Governments and the Central Ministry of Education and an endeavour should be made to re-organise the pattern of education. We cannot really say more than what the Sampurnanand Committee has said on the difficulties in the present organisation of education. But we are aware that the State Governments and the Ministry of Education have also been seized of the problem and the Central Advisory Board of Education through its Standing Committee is trying to arrive at a reasonable solution.

5.06. In broad terms, however, we make the following suggestions :

(1) Science education in the *primary schools* should be introduced in the form of nature study. Not less than 25% of the lessons in the different language readers could be devoted to science subjects in the form of stories, explaining the phenomena in nature as well as the lives of great scientists who have contributed to the making of the modern world. Such lessons should not however lack in literary presentation and grace to stimulate creative talent of the pupil. Use of visual aids, visits to botanical and zoological gardens and other methods of instructions have to be employed as far as feasible. Besides, in the reorganization of syllabus for primary schools some science teaching has to be introduced in an elementary form. A Committee like the one in U K. should study the syllabus for "Science in Primary Schools' and should submit a report to all States for their consideration and acceptance with any modification. The Ministry of Education with the assistance of the National Council of Educational Research and Training should undertake this.

5.07. (2) General science courses could be started in the *middle schools*, *i.e.*, classes VI, VII and VIII.

The real difficulty at this stage is that of formulation of curriculum and syllabus and prescription of suitable textbooks, preparation of the lists of laboratory equipment and establishment of proper laboratories and libraries In broad terms again we should

like to suggest that the emphasis here should be on general knowledge and the proportion of time to be given to subjects like mathematics, geography, general science including physics, chemistry, biological science, etc , along with humanistic subjects like language (*i.e.* English, Hindi, Indian language etc.) should be properly envisaged and should have a standard content in all the States For this purpose, it would be desirable to have consultation with the State Governments at the Centre and a policy regarding contents of courses should be evolved in such a way as would be acceptable to all the States and certain uniformity established about these courses. It should not be hard for a student migrating from one State to another to adapt himself or herself to the pattern of courses in a State where he/she migrates. And secondly, it should be possible to have textbooks prepared for different classes covering uniform syllabus. There could be a variety of textbooks giving illustrations and, perhaps, simplified approaches to explain the content of the subject But the syllabus covered should be the same in all the textbooks accepted in the different States in different languages. No attempt at specialisation in any subject should be made at this stage.

While we have said this, we do not want to suggest that a dead uniformity of courses will help teaching of general science as local environment—urban and rural, industrial or non-industrail, mountain, plain and sea-shore—will have to be taken into consideration. There has to be a broad curriculum and the teachers should have the choice to teach the subject in accordance with the local conditions and the emphasis should be laid on methodology of science rather than covering a fixed curriculum.

It is recommended that the Committee mentioned above may examine this problem or a separate one may be appointed to suggest concrete steps.

5.08. (3) At the *High School* stage science should be compulsory for all students, but it has to take the form of separate subjects as mathematics, physics, chemistry, biological sciences, etc., along with the other humanistic subjects. Certain guidance in this connection could be offered by the way in which courses have been prescribed in the U S.S.R. While formulating the courses it should be seen that there is a balance between the courses

in science and courses in humanistic subjects and the one does not out-weigh the other This should remove defects of early specialisation and everyone who leaves the High School should be equipped with elements of science as well as of humanistic culture, whether he goes into employment or further courses in higher education or junior college instruction or in courses of vocational education in the trade schools, polytechnics or various other branches of vocational training which will expand as our economy progresses

Our real approach in emphasising science teaching at this stage is how it has been explained some time ago by Bertrand Russell in a statement that science today holds the same position in our culture as the classics held in the medieval and pre-industrial revolution period in Europe. A classics man was considered to be a well-educated person in earlier times In modern times a man with the knowledge of mathematics, physics, chemistry, biology, etc., might be known as an educated person

At the high school stage or higher secondary stage of one year more, or junior college stage of Intermediate level of 2 years, after high school, as this pattern is likely to come during the next 15 years, we have to provide two kinds of science courses (i) general science, compulsory for all at the lower stage to enable every citizen to understand the modern world and (ii) optional or elective science for those who are going to adopt a career requiring scientific knowledge or of applied science like engineering, medicine and agriculture.

5.09. (4) A decision will have to be taken regarding the nature of the higher secondary stage. If the trend is to follow the recommendation of the Sampurnanand Committee, it will be possible to have new institution of junior colleges or intermediate colleges attached to the colleges or high schools or independent with a 2-year curriculum consisting of the 11th and 12th classes. In that case, specialisation in science could be started at this stage for those students who would go in for professional courses of medicine, agriculture, engineering or degree courses like B.Sc. and M.Sc. in science itself. The courses will have to be, perhaps, of the same nature as adopted for the VI form in the U.K. where boys spend at least 2 years, but very often 3 years in doing

courses at advanced level for admission to the universities and other institutions of higher training.

5.10. However, this would mean taking a decision which might take some time after long deliberations. We understand that the University Grants Commission and the Conference of the Vice-Chancellors have felt that the total duration of course of education should be 15 years in the school and the college which may be 11+4 or 12+3. The 12 may be 5+3+2+2 and 11 may be 5+3+3. However, this matter has already been explained in Chapter III, paras 3.07 and 3.08.

5.11. (5) In our opinion, specialisation at an early stage of school education should be avoided and courses of instruction should be so framed as to enable those who come out of the high schools at the age of 16 plus or 17 after completing 10 years of schooling either to pursue an occupation or training programme suitable to their aptitude or to undertake further higher academic course. At present in some States the tendency is to offer options at an early age of 14 plus and a student very often has to decide whether he takes the subjects in arts or science or commerce at that tender age. This we consider to be un-balanced and un-educational. At the same time some bias should be given at early stage of education at appropriate levels suited to aptitude and capability of the student. This would be a matter of properly balancing courses of study.

5.12. (6) *Modernisation of school curriculum*—We learn that in the syllabus today as obtained in a number of States the courses are pretty out of date and modernisation of school curriculum is a complicated problem. We, however, feel that this should be settled by the State Governments with the advice of the Central Ministry of Education immediately and the process of making these courses uptodate should be a continuous one for, as stated by the Crowther Report, "periodical revisions of the intellectual diet are necessary."

5.13. (7) *Science textbooks*—The problem of textbooks in science subjects has been mentioned earlier and has to be examined by the State Governments and the Central Ministry of Education and Planning Commission with a view to seeing that there

is no scarcity of suitable textbooks and authors are encouraged to prepare them. Energetic action at the State and national level is required to make progress in the preparation of the high quality school textbooks. Real good teachers are a very scarce commodity and, therefore, textbooks, demonstration apparatus and other teaching aids should be so organised as would make it possible for a teacher of average quality to impart proper education in content and quality. The basic point appears to be that the content of syllabus has to be directly related to good textbooks and if possible to competent teachers. Since the latter will be difficult to obtain, textbooks and teaching aids have to be introduced in such a way as to enable good students to be guided by them with whatever instruction they would get from the teachers.

5.14. We are glad to learn that the National Council of Educational Research and Training has in its programmes given the highest priority to the preparation of good textbooks in science for secondary schools.

The Council has constituted panels of specialists, one each for physics, chemistry, biology and mathematics. The specialists who are members of the panels are drawn from different parts of the country and the panels also associate secondary school teachers in their work.

It is proposed to bring out the textbooks prepared by the panels in an experimental edition so that the books may be tried out in selected schools all over the country and discussed in detail with secondary school teachers and others connected with secondary schools. The books in their final version will be prepared in the light of the experience gained from the try-out Thereafter, the panels will develop Laboratory Guides as well as Handbooks for Teachers.

5.15. For General Science the Council has prepared a draft syllabus for classes I—VIII with the help of teachers and specialists. It has been printed and is being circulated to selected schools to elicit their reactions. A book of experiments to accompany the syllabus is already under preparation. Thereafter, the Council proposes to have textbooks prepared for the elementary classes.

5.16. We commend the programme that the Council has initiated and are particularly glad that it reflects recognition of the fundamental need to bring the specialists in the universities and the secondary schools closer together in the attempt to provide improved books for secondary schools. Of equal significance is the idea of trying out the books in a few selected schools before they are given their final form. We hope that the State Departments of Education will take full advantage of the books that are being prepared by the Council and recommend that the introduction of these books in the schools should be preceded by a systematic training of the teachers so that the textbooks may not merely represent the replacement of one set of books by another but become the base for a self-enforcing programme of improved science education in the schools involving orientation of the teaching methods to the scientific experimental approach and a system of assessment and examinations which would emphasise the essential nature of the scientific process and its application rather than mere facts and bits of information.

5.17. The National Council of Educational Research and Training is also planning to bring out a series of books on scientific topics intended as supplementary reading material for secondary school pupils. Specialists are being invited to write books on topics lying within their field of specialisation. It is also proposed to include in the series by reprinting a few outstanding books of foreign publications. We hope that this projected series of supplementary reading material will be developed early and will be available in as many Indian languages as possible.

5.18. (8) *Summer Institutes for secondary school teachers*— In the summer of 1963 the University Grants Commission and the National Council of Educational Research and Training collaborated in organising four Summer Institutes or vacation courses for secondary school teachers. These courses were in physics and mathematics organised in the University of Delhi, chemistry in the University of Poona and biology in the University of Madras. In order to help the secondary school teachers to get acquainted with modern developments in the teaching of science the Summer Institutes examined and analysed the textbooks and other materials which have been prepared in the U.S.A. through a series of

important projects The experience gained in these four Summer Institutes was presented to a Conference of State Education Secretaries and Directors of Education in June 1963.

It is now proposed by the Council to organise 16 Summer Institutes in the coming year where the textbooks and curricula developed by the panels referred to earlier would be discussed with secondary school teachers.

5 19. The programme of Summer Institutes for secondary school teachers and the collaboration that it provides between the universities and the secondary school system represent a very promising development which we hope, will be extended as quickly as possible to all universities, so that the coverage may be such as to have a real impact on the secondary schools all over the country. It is of utmost importance that the secondary school teacher should be helped to make himself acquainted with the latest developments in his subject, because nothing contributes more to improved methodology of teaching than a mastery of the subject-matter and the mental stimulation that knowledge of advancing frontiers provides.

5 20. (9) *School buildings and laboratories*—We are aware that at present quite a number of school buildings are lacking in physical facilities of laboratory equipment, apparatus, library, etc., and the building itself has not been devised from a functional point of view in many cases While some work has been done by the Committee on Plan Projects of the Planning Commission on school buildings, hostels, science laboratories and equipment, we recommend that as leadership in science education has to be taken by the universities and university professors, the continuous study of the problem has to be taken by an organisation responsible for academic standards. A considerable amount of literature is available in advanced countries of this problem and in U.K. functional utility and efficiency have increased in secondary schools by new plans designed and adopted We recommend that University Grants Commission is most concerned with leadership in science education and they should have a cell which will continuously study the problem of designing plans of buildings and laboratories for colleges and high schools.

5.21. (10) *Expenditure on pupils*—Our attention has been drawn to the increasing burden on science students who have to buy not only the costly textbooks, but also costly apparatus. While we have already indicated our approach to textbooks we feel that production in larger numbers should enable the publishers to reduce the cost of books. Similarly, simplest apparatus should also be made available to students by educational authorities concerned.

5.22. (11) *Examinations*—We have noted with satisfaction that examination reform is attracting the attention of educational authorities today, but we are interested in actual results. So far as science education is concerned, it is suggested that records of students and their practical work in the laboratories or in the classroom should carry enough credit to enable the student to pass to the higher stage or higher class along with other credits that he would collect throughout his course of study.

5.23. (12) *Teachers and conditions of service*—The key issue is the availability of teachers and their education and training. Syllabus, however well-founded, might be completely negatived by teachers of poor quality. The problem of teachers' salary and the conditions of service have already been engaging the attention of different authorities concerned, but we think that both training of science teachers and their conditions of service have to be undertaken as a problem of study by the Ministry of Education and recommendations made so as to see that recruitment of such teachers will not cause much difficulty to State Governments.

5.24. We specially would like to draw the attention of the State Governments and the Central Ministry of Education to the following and we have no doubt that they would take necessary steps to remove the difficulties.

(i) Museums of science should receive more attention than at present.

(ii) Need for introducing hobby workshops.

(iii) The need for preparing a handbook for teachers of science which should give instructions to teachers in regard to the teaching of their subjects. Such a handbook should be prepared by experts and we feel that

it could be appropriately taken up by the National Council of Educational Research and Training.

(iv) Similarly, there could be special handbooks and informative books prepared for the students in simple language. Publishers in the private sector as well as various textbooks research bureaux should be encouraged to take up this activity.

(v) Periodical conferences should be organised at the State and Central levels of science teachers and experts as well as administrators to review the position in regard to progress of science education and suggest steps to improve it further.

(vi) If financial provision is the only difficulty in many cases, it should be analysed in full details and authorities concerned should be apprised of the position to enable them to include provisions in the annual budgets. This will involve administrators at the State and Central levels and the Planning Commission.

We cannot make suggestions regarding the details of the course of action which should be taken by the State Governments for the problems would vary from State to State

APPENDIX

List of Participants in the Study Group Meetings on Science Education in Schools

1. Shri H. C. Dasappa, M.P. — *Chairman*
2. Prof. H. N. Mukerjee, M P.
3. Dr. Tara Chand, M.P.
4. Shri Ganga Sharan Sinha, M.P
5. Shri R. P. N. Sinha, M.P.
6. Shri C. R. Basappa, M.P.
7. Shri Patil Putappa, M.P.
8. Dr. K. L. Rao, M.P.
9. Shri A. N. Vidyalankar, M P.
10. Shri Basant Kumar Das, M P
11. Shri Sham Lal Saraf, M.P.
12. Dr. H. K. Mahtab, M.P.
13. Dr. M. M. S. Siddhu, M.P.
14. Shri M. Ruthnaswamy, M.P.
15. Dr. M. S. Aney, M.P.
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17. Shri M. Malaichami, M.P.
18. Shri P. R. Ramakrishnan, M.P.
19. Shri Tekur Subrahmanyam, M.P.
20. Shri N. R. Ghosh, M.P.
21. Shri K. K. Warior, M.P.
22. Shri Jagannath Rao Chandriki, M.P
23. Prof. A. R. Wadia, M.P.
24. Shri B. N. Bhargava, M P.
25. Mrs. Savitri Nigam, M.P.
26. Dr. Jawaharlal Rohtagi, M.P.

27. Prof. Mukut Behari Lal,
28. Shri Y. P. Mandal, M.P

Experts

1. Dr. A. N. Khosla
2. Dr. D S. Kothari
3. Shri P. N. Kirpal
4. Dr. A. C. Joshi
5. Shri K. L. Joshi
6. Shri Raja Roy Singh
7. Dr. K. P. Basu
8. Shri K. Ray
9. Mrs. S. Doraiswamy
10. Principal M. N. Kapur
11. Dr. B. D. Jain

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